GEOGRAPHICAL INTRODUCTION.

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(With Plates I–II.)

Seistan and the Helmand River.

The Persian district of Seistan, at periods in its history an independent state and at others a part of Afghanistan, lies roughly between long. 61° and 62° E., lat. 30°50″ and 31°50″ N.; but its precise boundaries are not delimited to the west and south. It consists of the delta of the R. Helmand and the Hamun or basin into which that river flows. These lie, surrounded on all sides by stony desert, in a depression less than 2000 feet above sea level. The Helmand rises in the Hindu Khush in about lat. 68°40″ and long. 34°30″ and flows for three hundred miles through the mountains of Afghanistan, receiving many tributaries on its way. It then debouches on the desert plateau of Registan and, some distance after doing so, is joined by its largest tributary, the Arghandab. The course of the united waters, which flow in a deep bed through the desert, is S.S.W for some seventy miles. They are then deflected by a small range of hills through which they have been unable to cut their way, and continue westward, with a distinct southward bend, for about another hundred and fifty miles. Then, on reaching the southern limits of the old delta, the river breaks up into innumerable channels, partly natural, partly artificial, which turn northwards. In these channels, the chief of which is ultimately known as the Rud-i-Pariun, much of the water is dissipated, but what remains finally drains westward into the Hamun-i-Helmand or Hamun-i-Seistan, a large basin (or rather series of basins) which occupies a considerable but extremely variable area. After the junction of the Arghandab and the Helmand very little additional water, not nearly enough to compensate for evaporation, enters the system; for the desert is practically rainless, even in Seistan the rainfall is only a

little over 2½ inches a year,[1] and there are no permanent affluent streams. Seistan is a well-watered country, but its water-supply, like that of Egypt, depends not on local rainfall but on the rainfall and the snows in a mountainous region many miles away. The fact that, unlike most of the lake-systems of Central Asia and Persia, that of the Hamun-i-Seistan has not dried up is to be explained only by the peculiar course of the Helmand, the greater part of which traverses comparatively damp mountainous country.

The Hamun, however, is not the final repository of the soluble matter which the river inevitably brings into it. If it had been so, with its limited area, all its water would have been salt long ago. On maps of Persia and the adjacent countries a river, named the Shelagh (or Shila) river, is marked running southwards and eastwards from the Hamun into another basin, the Gaud-i-Zirreh, which occupies a very large area in the great desert of south-western Afghanistan. This is the Dead Sea of the

[1] The following tables of rainfall (in inches) are derived from official sources :—

Season.	Quetta.	Chaman.	Hindu Bagh.	Kabul.	Seistan.	Meshed.	Teheran.	Baghdad.
October to March ...	7·58	8·06	4·51	8·45	2·06	5·01	7·93	7·14
April to September ...	2·40	1·72	0·81	3·40	0·45	3·49	1·92	1·20
TOTAL ...	9·45	9·78	5·32	11·85	2·51	8·50	9·85	8·34

RAINFALL AT NASRATABAD, SEISTAN.

Month.	1902.	1903.	1904.	1905.	Total.	Average per month.
January ...	...	1·46	0·60	0·44	2·50	0·83
February ...	Not recorded.	0·42	0·15	0·28	0·85	0·28
March ...	...	0·97	0·19	0·37	1·53	0·51
April ...	0·03	1·19	...	...	1·22	0·41
May ...	...	0·05	...	...	0·05	0·02
June ...	...	0·07	...	...	0·07	0·02
July ...	...	...	...	...	...	...
August ...	...	...	...	...	...	...
September ...	...	...	...	...	...	...
October ...	0·27	...	...	...	0·27	0·09
November ...	0·17	0·07	0·06	...	0·30	0·10
December ...	0·60	0·13	0·01	...	0·74	0·25
TOTAL ...	1·07	4·36	1·01	1·09	7·43	2·51

Helmand system.[1] Except in times of exceptional flood the Shelagh is a deep stream-bed, dry except for scattered pools of water so saline that tamarisk twigs at the edge are coated half an inch thick with salt; but the water in flood-times, at the very site of these pools, becomes readily drinkable and the river is a raging torrent. Similarly the Gaud-i-Zirreh is at most seasons a wide plain covered with a thick deposit of salt and containing pools and swamps of saline water; but it may become a real lake for the time being, with water of comparatively but not actually low salinity.

The climate of Seistan, though regular from year to year, is one of considerable extremes and with only two seasons, summer and winter. In December and January the temperature usually falls below freezing point at night, while in summer it frequently rises to 115°F. in the shade by day, with a maximum of about 117° It is, however, very exceptional for the larger bodies of water to freeze completely, while the summer heat is tempered by an almost unceasing wind. Wind,[2] indeed, seems to be the most constant feature of the climate, and its direction seldom changes. The direction is about N.N.W For weeks on end in summer time it does not stop, and even in winter windy days are commoner than calm ones, and the wind is as a rule practically N.N.W Such rain as falls, falls mainly between the end of December and that of April, in which thunderstorms accompanied by hail and causing sudden floods sometimes occur; but the real flood-season takes place when the snows begin to melt in Afghanistan between March and May.

Different Types of Aquatic Environment in Seistan.

A summary description of the Helmand-system and the climate of Seistan has been necessary to explain the very existence of the Hamun-i-Helmand as a lake, and of an aquatic fauna in the country. A detailed account[3] of the system would be impossible

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[1] In high floods a certain amount of water runs from the Helmand direct into the southern part of the Hamun system through a channel probably of artificial origin, and in exceptionally high floods some may flow direct into the Gaud-i-Zirreh, but this is not the normal course.

[2] "At the end of May, or middle of June, the celebrated *bad-i-sad-o-bist rus* (120 days' wind) sets in and blows with but little cessation till the middle or end of September. It blows unceasingly for four or five days at a time, usually attaining its maximum daily velocity between midnight and 5 A.M and again between 8 A.M. and 5 P.M. It moderates a little in the early morning and evening. After four or five days it drops a little for a day or two, only to recommence with renewed violence. It blows with appalling violence, reaching the maximum velocity. as recorded by the Mission anemometers, of 72 miles per hour. It blows always from one direction, viz. a little west of north, i.e. between $316\frac{1}{2}^{\circ}$ and $333\frac{3}{4}^{\circ}$." (From an official document).

[3] The most complete account of the topography of Seistan yet published is to be found in Tate's *Seistan. A Memoir on the History, Topography, Ruins and People of the Country*, Parts I–IV (Calcutta, 1910 and 1912). See also McMahon "The Southern Borderland of Afghanistan," *Geog. Journ.* IX, pp. 393–415 (1897), *id.*, "Recent Survey and Exploration in Seistan," Vol. XXVIII, pp. 333–340 (1906), and Rawlinson "Notes on Seistan," *Journ. Roy. Geog. Soc.* XIII, pp. 272–294 (1873).

without further knowledge and greater space than are at my disposal. It is necessary, however, if the peculiarities of the fauna are to be demonstrated that a somewhat fuller description should be given of the physical conditions in which it lives. I have referred to Seistan as a well-watered country. One might go further and describe it as almost a water-logged country; and yet at first sight, at any rate in winter, it appears to be a desert of hard grey clay, only clothed with a sparse growth of camelthorn, only mitigated by the astounding play of the mirage. The apparent barrenness is because the soil is full of mineral salts dissolved in the water which permeates it a few feet below the surface. By capillary action the salts are drawn up towards the surface and assist in forming a hard, almost cement-like crust, which has to be removed before the operations of agriculture become possible. If a field or a garden be neglected for a few years a new crust of the kind is formed, and so it is only those parts of the country actually under cultivation that have any appearance of fertility.

The whole country is covered with a network of small water-channels ultimately connected with the branches or effluents of the Helmand. In these the flow of water is carefully regulated and for a great part of the year many of them are permanently or periodically dry. Even in their immediate vicinity the clay is almost lifeless. It is only in exceptional cases that the channels themselves support an aquatic vegetation, but in the one that supplies the Consulate garden at Nasratabad, there is a sparse vegetation of Characeae and *Potamogeton*, while in brick-pits close at hand on the parade-ground *Zannichellia palustris*,[1] L., grows with fair luxuriance. A green filamentous alga is more common and forms felt-like masses as it dries. These masses are often seen coating and sometimes completely burying the camelthorn in occasionally flooded country.

We did not have time to visit the main channels of the Helmand, but at a place near Jellalabad about twelve miles north-east of Nasratabad we examined the bed of one of the larger effluent streams. At the end of November, 1918 this stream-bed was almost dry, but shallow pools remained in which the water, though not very salt, was turbid and extremely foul owing to the presence of large flocks and herds which watered at the pool, and to the enormous number of small fish and mayfly larvae (*Palingenia*) that were dying in it. There was no vegetation in an active state in these pools, but peculiar roots with large globular swellings were still alive in the mud, and we found at some places the remains of reeds. Still nearer Nasratabad we examined a narrower but more active water-course, probably in part of artificial formation, which was connected with a small lake or large backwater. In this lake the only vegetation consisted of reeds in a withered condition, but

[1] I have to thank my friend Dr. H. G. Carter for the name of this and other plants mentioned in this report.

near it was a smaller pool in which were scattered plants, almost moribund, of a species of *Potamogeton.*

By far the most peculiar and most interesting body of water in the country, however, is that which occupies the Hamun. To appreciate the structure of the Hamun it must be realized that the word means lake-basin rather than lake, and is sometimes applied to large hollows that are quite dry. Moreover, in Seistan at any rate, it is used in a collective sense to indicate a whole series of basins only joined together in high floods. In this sense the full name is the Hamun-i-Seistan or Hamun-i-Helmand, but it is common to speak merely of the Hamun. On some maps of Persia and the adjacent countries the Helmand is shown as flowing into a compact body of water some eighty miles long and from ten to thirty broad. This state of affairs, however, only exists in exceptionally high floods and probably does not occur more than once in a decade. The Hamun is ordinarily divided into several distinct basins, of which two may be recognized as of most importance and most distinct. These may be conveniently referred to as the Hamun-i-Sabari and the Hamun-i-Koh-i-Khwaja. The Hamun-i-Sabari,[1] to use the name in the wider sense in which it is often used in Seistan, is the northern half of the Hamun-i-Seistan, and the only part of it that contains water not strongly saline at any season but flood-time. It rarely dries up completely. In normal winters it probably covers an area about ten to twenty miles long by six to twelve miles broad. The Rud-i-Pariun and other branches of the Helmand enters this basin on the eastern side. It is separated from the Hamun-i-Koh-i-Khwaja by a broad bar which is, except in flood-time, quite dry. Except at this season, the southern basin is dry or contains only pools of strongly saline water. It is only when the Hamun-i-Sabari overflows that it fills up, and when it itself overflows the Shelagh becomes a real river.

At the time of our visit the Hamun-i-Koh-i-Khwaja was said to be almost completely dry and we did not visit it. I shall confine my further remarks on the Hamun system, therefore, to the Hamun-i-Sabari. Of this lake we visited only the southern part, the northern extremity lying in Afghan territory.

The shores of this part of the Hamun are for the most part low and shelving, composed of mud more or less firmly caked and with frequent beds of reeds. Along the western shore there are, however, cliffs in some places over 50 feet high. The water reaches the base of these cliffs only in very high floods and the beach below them is strewn with water-worn pebbles. They are themselves composed of hard greenish-white clay formed of

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[1] On most maps, including those issued recently by the Survey of India, this name is confined to the extreme northern part of the system, which is often isolated if not completely dry, the more important basin into which the waters of the Helmand actually flow being left nameless. At Lab-i-Baring, however, the whole lake is called Hamun-i-Sabari.

very fine particles of even structure.[1] Along their summits a comparatively thin layer contains numerous pebbles similar to those that cover the surrounding desert,[2] and it is from this layer that the pebbles of the beach are derived. The cliffs themselves are being continually eaten away by wind and occasional rain and undermined by floods, which cause great blocks of clay to fall down on to the shore.

No trace of shells or other animal remains has been found in the clay of the cliffs. The clay of the bottom of the open lake in their vicinity is very similar in general appearance though naturally much softer, but contains empty shells of *Lamellidens* and *Corbicula* in a remarkably unworn condition.

The normal flood-level is marked on the shores of the lake by a drift-line consisting mainly of the broken stems and the inflorescences of reeds.

Perhaps the most prominent feature of this part of the Hamun is the enormous beds of reeds that cover a large part of its area. These reeds are of three kinds. Each kind grows separately but beds of each are to be found in the midst of those of the other two. The most abundant species is a form of *Phragmites* exactly intermediate, as my friend Dr. H. G. Carter informs me, between the Palaearctic *P. communis* and the Indian *P. kharka.* This reed covers hundreds of square miles in the flood season and gives its name (*nai*) to the Naizar or reed-country that affords valuable pasturage for sheep and cattle. When the floods sink the reeds die down as the soil dries, but those that have established themselves in deeper water flourish throughout the year. Next in abundance is *Scirpus littoralis*, which also covers large areas but does not extend so far out from the lake, and finally we have a bulrush of the genus *Typha*, which is rather less abundant than the other two species.

The reed-beds provide the means of life to two distinct classes of people who live on the shores of the Hamun—the Gaodar or cowherds and the Saiyads or hunters. The Gaodar have large herds of cattle, which they feed on the young shoots of *Phragmites* and *Typha*, both fresh and dry, and particularly on the *Scirpus.* Both tribes construct their dwellings entirely of *Phragmites*, and both make curious little skiffs, not unlike the papyrus skiffs of ancient Egypt, of the leaves of the bulrush—the only craft on the waters of Seistan.

The reed-beds are penetrated in all directions by narrow channels said to be made by the cattle of the Gaodar wading out to pasture, but probably kept open by the people themselves for use in bird-catching and fishing. The water in these channels is turbid near the shore of the lake but clear and of a yellowish tinge

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[1] For sections of the cliffs of Seistan see Huntington's account of "The Basin of Eastern Persia and Seistan" in *Explorations in Turkistan* (*Expedition of* 1903), published by the Carnegie Institution of Washington (1905).

[2] See Vredenburg, *Mem Geol. Surv. Ind.* XXXI, p. 179 (1901).

further among the reeds. The bottom is covered with a thin layer of peaty material, below which it is malodorous and black. It is as a rule from four to seven feet deep in the winter season. The channels widen out at intervals into open pools of two sorts, the larger of which are devoid of phanerogamic plants. Those of the smaller sort, which are rarely more than about six to ten yards wide, are rather deeper than the channels and are blocked with aquatic vegetation. This consists mainly of *Potamogeton pectinatus*, which with its narrow, grass-like leaves forms fairly dense masses from the bottom to the surface. Interspersed with it are single plants of *P. perfoliatus*, *Naias major* and Characeae. In the channels themselves single plants of *P. lucens* and at some places rather more densely congregated plants of *Vallisneria spiralis* form the only phanerogamic vegetation apart from the reeds.

The reeds act in all the channels and pools as a very effective wind-screen, so that even when a blizzard is blowing outside there is calm in the reed-beds. They also protect the water to some extent from frost.

Immediately outside the reed-beds, towards the open lake, there are at some places beds of *Potamogeton perfoliatus*, but the bottom of this part of the lake is usually bare. In calm weather the water is clear, but calm is exceptional in Seistan and as a rule it is turbid and of a milky appearance.

All the subaqueous plants of the Hamun are in a more or less moribund state in winter, the *Vallisneria* and *Potamogeton pectinatus* less so than the rest. Of the other species we found only occasional living shoots.

In the southern part of the Hamun-i-Sabari we made no sounding greater than 7½ feet, but rather deeper pockets are said to exist further north. It will be remembered, moreover, that our visit took place at the season at which the lake is almost at its lowest.

From a biological point of view the periodic and occasional changes in the level of the lake are of great importance. These are produced mainly by two causes, evaporation and changes in the supply from the Helmand due chiefly to the rate of melting of the snows of the Hindu Kush. The direction of the wind is so constant that its effects need not be considered. When it ceases to blow the water retreats a little but the result is quite temporary. In the year 1885, in which the Hamun was unusually full, the water reached its maximum in April, remained at its highest level up to the end of May and sank a little over three feet between that month and December.

In a climate like that of Seistan the loss of water by evaporation is very considerable in summer-time. The actual rate of evaporation apparently differs in different parts of the country in correlation with differences in the chemical composition of the water, being in the Gaud-i-Zirreh half of what it is in pools in the northern parts of Seistan. The whole question, however, is very

imperfectly understood and calls for further investigation. By calculation about ten feet of surface water should be lost annually from this cause in Seistan proper, but observations show that the actual amount is considerably less.

The loss of water through occasional failure of the Helmand supply is still more important to the aquatic fauna of the Hamun. Both fish and molluscs are said to have been abundant at one time in the lake, but it dried up completely in 1871 and again in 1903,[1] and since these dates the fauna is believed to have become much impoverished.

There is only one other kind of body of water to which I need refer here, viz. the springs that well up in the stony desert surrounding Seistan. These springs vary considerably in size and in salinity. None of them possess any great volume of water and few are quite fresh, the majority containing a more or less strong solution of magnesium sulphate, which has a devastating effect on the entrails of those who drink the water. An exception to this is to be found in the spring at Hurmuk, just across the Persian frontier and only a few miles from the point at which those of Persia, Afghanistan and Baluchistan meet. The water of this spring, which is fairly copious, is fresh and is stated locally to be the best in all Iran. Whether they be fresh or salt these springs are usually devoid of aquatic vegetation other than algae, at most, as at Saindak, having a scanty growth of *Potamogeton*, but a small *Scirpus* often grows at the edge, and the water is usually edged with willow trees (*Salix acmophylla*), perhaps planted. As a rule there is a small pool, more or less artificial, where the water comes out of the earth, with a streamlet or mere trickle passing from it into the desert and disappearing at no great distance.

Origin of the Hamun-i-Helmand.

It would be out of place in the present paper to discuss the geological history of Seistan[2] in any great detail, but there is one problem, that of the age of the Hamun, which has too important a bearing on the origin of the aquatic fauna to be entirely ignored. It has sometimes been assumed that the Hamun is the shrunken relic of a great freshwater lake, which has even been compared to the Caspian Sea. As I have already pointed out (*antea*, p. 4) the existence of a lake of practically fresh water in Seistan is to be explained by the peculiar course of the Helmand and by the fact that the whole system is occasionally flushed into the Gaud-i-Zirreh, and if, as the body of evidence[3] seems to show, the whole of

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[1] Huntington, E., "The depression of Seistan in Eastern Persia," *Bull. American Geog. Soc.* XXXVII, p. 276 (1905).

[2] See Huntington's account of "The Basin of Eastern Persia and Seistan" in *Explorations in Turkistan* (*Expedition of* 1903) published by the Carnegie Institution of Washington (1905).

[3] There is an extensive literature on this subject. For a good recent summary see the chapter on "The Ancient Climate of Iran" in Huntington's book "The Pulse of Asia" (London, 1907). Blanford's volume on the *Zoology and*

Eastern Persia and the neighbouring countries have become desiccated in the recent period, we may be certain that the basin of the Helmand contained more water at a period geologically not remote than it does now. More water must have entered the river, there must have been less loss by evaporation and possibly less by absorption in recent alluvium. Moreover, the structure of the Afghan-Baluch desert leaves little doubt that lakes of considerable area once existed within its confines, even if it never formed a single great lake-basin. It needs no great exercise of the imagination, for example, to believe that the Gaud-i-Zirreh, which is over eighty miles long and some twenty miles broad, was once a comparatively deep lake, which gradually silted up, as most lakes do in the course of time. Further, the clay of which the cliffs at Lab-i-Baring at the edge of the Hamun-i-Sabari (*antea*, p. 7) are composed has all the appearance in its fine texture, uniform structure and lack of stratification, of being a lake deposit.[1] My friend Mr. E. Vredenburg of the Geological Survey of India, who has been kind enough to examine specimens of this clay, reports that they closely resemble that of certain tertiary deposits in the Siwaliks which he believes to be of lacustrine origin. I have pointed out above (p. 8) that, *except in being totally devoid of animal remains*, it closely resembles the deposit now being formed at the bottom of the Hamun in the immediate vicinity of the cliffs.[2]

This, however, does not prove that the existing Hamun is the actual remains of an ancient freshwater lake. All that it indicates is that the Hamun occupies part of an old lake-basin. As the cliffs are over fifty feet high, this old basin must have contained a large body of water and existed for a long period, in order that so much silt should have been deposited.

The structure of the cliffs at this place is uniform except for a layer of a few feet on the surface. This layer is composed of dry earth more friable than the clay beneath it and full of water-worn pebbles, either of limestone or of volcanic origin. The following report on specimens of the limestone pebbles by Mr. Vredenburg shows that they do not differ from those found in the neighbouring desert[3] (with which this layer is, indeed, in continuity both structurally and geographically), and that, therefore, they have been brought from distant hills by occasional floods and not shaped by the waves of a lake. Mr. Vredenburg writes:—

"The three pebbles of dark-grey limestone contain a few specimens of *Nummulites atacicus*, Leym., a fossil characteristic of

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Geology in Eastern Persia, pp. 448–451, may also be consulted and the reports of the Expedition to Central Asia organized by the Carnegie Institution of Washington.

[1] Huntington, *op. cit.*, 1905, p. 285.

[2] It should be noted in this connection that in the Siwaliks proper of the sub-Himalayan area, which were not formed under desert conditions, freshwater fossil shells are abundant at certain places. Precise information about the species, etc., is, however, still lacking.

[3] See Blanford, *op. cit.*, p. 465 (London, 1876), and Vredenburg, *op. cit.*, p. 189.

the "Lybian" division of the eocene, a stage widely developed throughout the Mediterranean countries, and intermediate in age between the "Londinian" and "Parisian" of North-Western Europe where it is missing.

"This species is very scantily represented in the pebbles under examination, which are crowded with an *Alveolina* that occurs in profusion in the Lybian limestones of India which, consequently, have frequently been referred to under the name of "Alveolina limestones." Carter (*Journ. Bombay Br. Roy. As. Soc.*, Vol. V, p. 134, pl. ii, fig. 16, 1853), and d'Archiac and Haime (*Descr. an. foss. groupe numm. Inde.*, 1854, p. 348) have regarded this fossil as specifically identical with *A. sphaeroidea*, Lam. (*An. sans vert.*, 1822, Vol. VII, p. 615), which abounds amongst the rocks of the same age in the Pyrenean region.

"The Alveolina limestone, showing the same dark colour as the Seistan pebbles,[1] occurs in great abundance in the neighbourhood of Koh-i-Malik-Siah."

From this it follows that the deposit of which the cliffs are a section must have completely filled up the basin in which it was formed, at any rate at the site of the cliffs, and had been covered by a layer of entirely different and more recent origin that constitutes the surface of the desert over a great area in Persia, Afghanistan and Baluchistan.

The lack of animal remains in the clay of the cliffs at Lab-i-Baring is a very important difference between it and the deposit now being formed in the Hamun in their immediate vicinity. The freshwater shells found subfossil in many parts of Seistan are in a remarkably good state of preservation, while those of the individuals that still live in the Hamun are so free from erosion that even in adult individuals of *Lamellidens* the larval shell of the glochidium can often still be distinguished. It is, therefore, very improbable that shells, if they had ever existed in the cliffs, would have been completely destroyed. The lake of which the cliffs represented the bottom can, indeed, hardly have had a molluscan fauna. In this respect it resembled most Persian lakes, and the reason of its barrenness was the same:—its water was too salt, or rather contained too large a proportion of deleterious[2] salts in solution. The clay of the cliffs is consolidated with mineral salts and the little streams that arise in clay hills of exactly the same structure and run down through little gorges towards the lake contain water of such salinity that the salts crystallize out at their margin (*postea*, p. 15).

Now, the waters of the Helmand are fresh and those of Seistan become saline when they absorb salts from the soil. This was brought home to us in a very striking manner at Lab-i-Baring.

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[1] These pebbles have probably been brought by occasional floods from hills lying a considerable distance to the west or north-west of the lake.

[2] The macroscopic fauna of the saline streams in the cliffs at Lab-i-Baring consists of a few small insects.

While we were staying there the wind dropped and there was a dead calm for three days. The wind had previously been blowing from the north, the direction roughly from the point at which the Helmand enters the lake, and the water of the Hamun had been quite fresh to the taste. As soon as the Helmand water, however, ceased to be blown in our direction, that of the Hamun became perceptibly brackish. As the present Hamun system has an occasional outlet into the Gaud-i-Zirreh and its waters remain, at any rate in the Hamun-i-Sabari, fairly fresh because of the scouring of the floods, we may suppose that the salts in the soil round the basin near Lab-i-Baring are derived from an old lake which had no outlet of the kind.

There is much historical evidence that the outflow of the Helmand has moved northwards in recent times. For example, there are ruined cities in the south of Seistan where there is now no water at all, while ruins are exposed in the bed of the Hamun-i-Sabari in times of exceptionally low water. In its course through the desert the river has gradually cut for itself a deep bed. Before it did so its course may have been quite other than it is now, and the filling up and desiccation of lake-beds may have been correlated in a complex manner with changes in level. It is by no means improbable on general grounds that the river, as the Jordan does now, once terminated in a saline lake which was practically lifeless. Indeed, there is evidence that it did so in the historical period. I have to thank Mr. Vredenburg for the following note on this point:—

"With regard to the change in the course of the Helmand, it seems possible that the northward bend at the Band-i-Kamal Khan may be partly artificial. From the historical evidence of Arab geographers, this spot must correspond with the original head of the delta which, originally, therefore, would have spread mainly over Southern Seistan and would have communicated more directly than it does now with the Zirreh Lake. It is nevertheless conceivable that the diversion may have been natural or partly natural; the shifting beds of the distributaries, both natural and artificial, being gradually raised by the deposition of silt, a process which might have gradually involved the whole of Southern Seistan till the main body of the Helmand found an easier course northward. The present Hamun-i-Sabari, in its present relatively extended form, would be therefore quite modern—as shown, indeed, by the ruined city in its bed; though a comparatively small and intermittent pool may have previously been formed by the flood-waters of the Farah-Rud. It is also quite conceivable that, as it became increasingly difficult to keep open the irrigation channels in Southern Seistan, the Helmand may have been artificially deflected northwards over the more easily watered northern tract.

"So long as the delta spread chiefly over Southern Seistan, the Zirreh Lake must have been much more obviously and much more permanently than it is now the true termination of the Helmand system. The true relic of the large prehistoric lake alluded to by

Dr. Annandale would therefore be represented by the Zirreh Lake and not by the adventitious bodies of water in Northern Seistan, which, in their present form, are perhaps not more than six or seven centuries old.

"Whether the Shelagh is the original outlet of the whole body of water in times of exceptional flood also appears somewhat doubtful, and it is also quite possible that it has acquired its present importance within late historical times as a result of the silting up of the eastern portion of Southern Seistan. Originally the exceptional floods need not have collected as they do now in a single channel, but may have reached the Zirreh Lake directly through the various distributaries of a delta. Much more information than is at present available would be necessary to settle these various points which nevertheless are of great importance and interest from the various points of view of history, geology and physical geography."

The fauna of the Hamun shows no evidence of ancient origin, or of evolution in a great lake. It is a very poor fauna, as may be seen most readily by comparing it with that of the lake of Tiberias, in which the water is actually salter though other conditions are rather more favourable. From the Lake of Tiberias [1] twenty-five species of fish are known, from the Hamun only two; from the former at least fifteen species of molluscs, from the latter only five; from the former two species of Polyzoa, from the latter the same number; from the former five species of sponges, from the latter two. Moreover, the fauna of the Seistan Lake is by no means a highly specialized one. The fish belong to genera common either in the mountains of central Asia or in those of North-western India, the molluscs are closely related to widely-distributed Palaearctic forms, the sponges are cosmopolitan, while the Polyzoa are closely related either to tropical or to cosmopolitan forms. Had this fauna been lineally descended from that of a great lake, I cannot believe that it would have shown no trace of its origin.[2] Moreover, subfossil shells found in the neighbourhood of the Hamun are identical with the recent ones.

From all these facts and lines of argument it seems to me evident, firstly that the Hamun occupies in part the bed of an old salt lake, secondly that it has only a casual connection with that lake, and thirdly that in its present state it is of recent origin. There has been no biological continuity between the old lake and the recent one. I am not particularly concerned with the history and origin of the former, but I suppose that they were similar to those of other lakes in Persia.[3]

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[1] Annandale, *Journ. and Proc. As. Soc. Bengal* (New Series), Vol. XI, Nos. 10 and 11, p. 437 (1915).

[2] See Annandale, *Rec. Ind. Mus.* XIV, p. 172 (1918).

[3] See the works of Blanford and Huntington already cited, and also de Morgan's note in *Revue de L'Ecole D'Anthropologie for* 1907 (Paris), pp. 214–215.

The Water of Seistan.

We collected a considerable number of samples of water in the Hamun-i-Sabari and other bodies of water in Seistan, but unfortunately several of the bottles were broken on our journey. By the kindness of Dr. H. H. Hayden, F.R.S., Director of the Geological Survey of India, the samples that remain have been examined in the laboratory of that department. They are not sufficient to ensure an accurate and detailed analysis, but indicate with sufficient clearness the general character of the salts present. Our sample of water from the Shelagh river was lost, but one of the salts crystallized on its shore has been analysed.

The following are the results :—

Analysis of Water Samples from Seistan.

	From south shore of Hamun about 4 miles east of Lab-i-Baring. Between reed-beds and muddy shore.	From a small saline stream running down to but not quite reaching the Hamun. About a mile and half north of Lab-i-Baring.	From edge of Hamun about one mile north of Lab-i-Baring. On stony shore below cliff.
Quantity received	560 c.c.	500 c.c.	470 c.c.
	Given in grammes per 1000 c.c.		
Al_2O_3 and Fe_2O_5	*nil*	Trace	*nil*
CaO	0·0496	0·8629	0·0345
MgO ...	0·2220	2·4476	0·1542
Alkalies weighed as chlorides ...	1·4640	20·2650	0·9100
Na_2O ...	0·721	10·683	0·313
K_2O	0·0664	0·069	0·201
Cl	0·5293	10·8985	0·3399
SO_3	0·4759	5·2136	0·2948
Suspended matter	0·0426 grammes	0·1200 grammes	0·0872 grammes.

Analysis of Salt from the edge of Shelagh River, near Girdhi, Seistan.

Amount insoluble in boiling water	29·78
Al_2O_3 and Fe_2O_3	0·10
Ca	4·64
Mg	0·27
Na	13·10
K	2·57
Cl	15·62
SO_4	22·39
CO_3	1·14
Water of Composition .	10·75
Total	100·36

From this report it is evident that considerable amounts of salt are present even in waters that are potable, as that of the Hamun near Lab-i-Baring; that the salt is not merely sodium chloride but of mixed composition, and that its composition varies greatly even in the same part of the Hamun in different circumstances. I have already noted the changes in salinity produced in the water by a cessation of the normal wind (p. 13, *antea*). In both samples from the Hamun salts of sodium are the most prevalent, but salts of magnesium, which are usually more deleterious to animal life, are present in considerable quantity, and in one sample those of potassium are also fairly well represented.

The sample of water from the small stream was taken about a hundred yards up from the beach of the lake, in a little gully in the clay cliffs. The stream was a very small one and rose in clay among small hills at no great distance from the lake. We may take it as representing a solution of the soluble salts in the clay of the cliffs.

The salt from the margin of the Shelagh river, on the one hand, represents the offscouring [1] of the whole Hamun system. Here magnesium is poorly represented, while both sodium and potassium are present in fairly large amounts.

We have as yet no data, therefore, to estimate the differential effect of water of different chemical composition on the aquatic fauna of different parts of Seistan, and, indeed, to arrive at any results of the kind would necessitate a very long and arduous investigation carried out through the seasons and under all possible conditions of flood and the reverse. All that can be said is that the aquatic fauna throughout the country lives in abnormal and variable types of environment so far as the composition of the water is concerned.

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[1] It cannot, however, be composed of the same proportions of the different salts that occur in the water in solution, for some salts crystallize out before others.